PHOTO INTERPRETATION REPORT

USGS-NPS VEGETATION AND INVENTORY AND MAPPING PROGRAM

ISLE ROYALE NATIONAL PARK

June 19, 2000

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I. INTRODUCTION

The National Park Service (NPS), in conjunction with the Biological Resources Division (BRD) of the U.S. Geological Survey (USGS), has implemented a program to "develop a uniform hierarchical vegetation methodology" at a national level. The program will also create a geographic information system (GIS) database for the parks under its management. The purpose of the data is to document the state of vegetation within the NPS service area during the 1990's, thereby providing a baseline study for further analysis at the Regional or Service-wide level. Aerial Information Systems (AIS) was subcontracted by Environmental Systems Research Institute (ESRI), the prime contractor, to perform the photointerpretation (PI) for the program. ESRI subcontracted The Nature Conservancy (TNC) to conduct the field sampling effort and to support the development of the National Standard Classification.

Several parks representing different regions, environmental conditions, and vegetation types, were chosen by USGS-NPS to be part of the prototype phase of the program. The initial goal of the prototype phase is to "develop, test, refine, and finalize the standards and protocols" to be used during the production phase of the project. This includes the development of a standardized vegetation classification system for each park and the establishment of PI, field, and accuracy assessment procedures.

This report outlines and describes the project timeline, PI methodologies, mapping criteria and data conversion procedures implemented in creating the final vegetation map for Isle Royale National Park.

II. GENERAL DESCRIPTION

Isle Royale National Park, established in 1931, was designated as one of the prototype parks for the Inventory and Mapping Program. The island, located in Lake Superior, is approximately 210 square miles is size and represents a “prime example of northwoods wilderness”. The park was designated in 1976 as part of the National Wilderness Preservation System. In 1981 the United Nations named Isle Royale a Biosphere Reserve.

Isle Royale National Park is an archipelago of islands located in the northwestern region of Lake Superior close to the United States-Canada border. The main island, Isle Royale, consists of a series of ridges and valleys running the length of the island and is surrounded by approximately 200 smaller islands. The primary methods of transportation on the island are hiking, with more than 164 miles of foot trails, and boating. See Figure II.1 Location Map.

Regional Outline

For the purposes of aiding PI and developing training sites for field reconnaissance, the island was divided into several regions on the basis of macro climatic-floristic divisions and regional breakdowns pertaining to major variations in geomorphologic characteristics. The regions are outlined below and followed by a section providing brief descriptions of each region.

<u>High Elevation Northern Hardwood Province</u>

- Major Ridges and South Facing Slopes
- Transitional Areas

<u>Low Elevation Boreal Conifer Province</u>

- Low Elevations Slopes and Near-Shore Environments
- Low Elevation Rocky Barrens and Ridges
- Mount Saginaw Jack Pine Stands
- Siskiwit Basin Region
- Offshore Islands

Region Descriptions

<u>High Elevation Northern Hardwood Province</u>

This portion of the island is located primarily west of Ishpeming Point at elevations generally above 1000 feet. The northern hardwood communities are best developed on the highest elevations especially on south facing slopes on interior ridges. These areas experience the least amount of direct influence from the cold waters of Lake Superior, which rarely exceed 10°C. Although precipitation in the form of snowfall is probably higher in these areas (orographic lift), this is not a limiting factor in the development of the northern hardwood communities. The absence of summer warmth may play a significant role in the limitation of northern hardwood types near the shoreline. Note similar comparisons using climatic data over a 30 year period: Houghton, located several miles inland, has a significantly higher number of cooling degree-days (base 12°C 330-July) than Grand Marais (base 12°C 192-July), located on the shore of Lake Superior.

- Major Ridges and South Facing Slopes

This region is generally restricted to the south facing upper slopes and ridges of the Red Oak and Greenstone Ridges west of Lake Desor at elevations above 1100 feet. The northern hardwood types are best developed in this region. The most extensive stands of the *Acer saccharum – Betula alleghaniensis* Forest Association were mapped on higher slopes along the western portions of the Greenstone and Red Oak Ridges. On upper south facing slopes generally above 1100 feet, small polygons were delineated and labeled with a *Quercus rubra – Acer saccharum* Forest Association. Initial field reconnaissance noted stands of *Quercus rubra* as a significant component to the sugar maple forests on rather xeric settings along the higher elevations of the Island Mine Trail. Other hardwood species noted as a minor component to the canopy layer in this area include *Populus grandidentata* and *Betula alleghaniensis*. Overall, approximately fifteen square miles of the Island have been mapped into several northern hardwood associations.

- Transitional Areas

Transitional areas generally form an elevation band of around 800 to 1000 feet surrounding the higher elevations of the Red Oak and Greenstone Ridges. These areas were also noted along southerly aspects on portions of the Minong Ridge west of Lake Desor and higher elevations of the Feldtmann Ridge. Extensive stands of *Betula alleghaniensis* have been mapped as a deciduous type or a mixed community on the lower slopes and ridges north of Feldtmann Lake and south of Windigo. Small polygons were mapped with the *Acer saccharum – Betula alleghaniensis* Forest Association on the Feldtmann Ridge and on ridges as low as 700 feet east of Windigo. In post burn environments north of Lake Desor, a successional forest community was mapped where *Betula papyrifera* formed a dominant canopy layer over *Acer saccharum*. This same *community (Populus tremuloides – Betula papyrifera / Acer saccharum*) was mapped where *Populus tremuloides* was the dominant canopy cover to *Acer saccharum* along the Island Mine Trail south of the Island Mine.

<u>Low Elevation Boreal Conifer Province</u>

Based on a floristic criteria, generally including everything except the four northern hardwood forest and woodland communities, the low elevation boreal conifer province makes up over 75% of the total area of Isle Royale National Park. The province includes the entire island east of Ishpeming Point with the exception of a few isolated ridges and south facing slopes along the Red Oak Ridge. Shoreline influences suppress summer temperatures and cold air drainage in large basins (Siskiwit and Moskey). West of Ishpeming Point, this province is restricted to elevations generally below 1100 feet. The four most extensive upland tree species (*Abies balsamea, Picea glauca, Populus tremuloides and Betula papyrifera*) in this region form five associations that have been mapped over a significant portion of the island. Together, these five associations (TNC project numbers 01, 23, 53, 54a, and 55) account for nearly half of the total 210 square miles of land mapped within the Park. Mesic upland communities containing a canopy component of *Thuja occidentalis* often in association with *Betula alleghaniensis* have also been mapped extensively in the western quarter of the island, especially in the Washington Harbor area.

- Low Elevation Slopes and Near-Shore Environments

This area forms a variable width band around the island generally below rocky ridges and barrens in the eastern portion of the park and below 1000 feet on gentle to steep slopes in the west. By far the most common communities in this region are found in the boreal hardwood forests and woodlands and the northern spruce–fir forests. In mesic north trending lower slopes and draws, *Thuja occidentalis* also becomes an important canopy species to the environment. In general, mesic conifer forests (*Thuja occidentalis – Betula alleghaniensis* Forest Association and *Thuja occidentalis / Abies balsamea – Acer spicatum* Forest Association) are more common in the west, along with more extensive stands of the sub-mesic *Picea glauca – Abies balsamea / Pleurozium schreberi* Forest Association, while mixed communities within the boreal hardwood forests and woodlands are found more extensively in the eastern portion of the island. Within this region, moderately extensive stands of *Pinus strobus* at times mixing with *Betula papyrifera* form an association (*Pinus strobus – Populus tremuloides / Corylus cornuta* Forest Association) on the low to middle slopes along the Minong Ridge.

- Low Elevation Rocky Barrens and Ridges

The low elevation barrens and ridges are found in narrow bands trending northeast–southwest along moderate to steep slopes and summits. The soil is thin or absent and supports several commonly mapped communities within the xeric woodland, shrubland and grassland environments. General locations are either in rocky outcroppings at or near the Lake Superior shoreline, or inland along summits and ridges. Nearly all the major ridges on Isle Royale contain significant outcroppings where these communities occur. A notable exception is the western third of the park where northern hardwood communities often form an uninterrupted continuum across the ridgelines. The most common sparse woodland types generally contain a strong component of *Picea glauca* over a sparse shrub and herbaceous understory layer.

Physiognomy is extremely variable among the sparse woodland and rocky shrubland types. The communities occur in complex and mosaic type patterns within small regions making mapping to the association level extremely difficult. In general, both the *Corylus cornuta – Amelanchier spp*. – *Prunus virginiana* Rocky Shrubland and *Juniperus communis* – (*Quercus rubra*) */ Juniperus horizontalis – Arctostaphylos uva-ursi* Shrubland associations were mapped much more commonly east of Lake Richie. Sparse woodlands containing *Picea glauca* were also mapped with greater frequency in this region. Although the "glade" type and the woodland were not separable on the photography, it is generally believed that sparser glades were more common in the eastern portion of the Island. Rocky outcroppings containing a sparse overstory of one to several species of pine with a co-dominant of *Picea glauca* (*Pinus banksiana* – (*Picea mariana*, *Pinus strobus*) / *Vaccinium spp*. Rocky Woodland Association) were difficult to separate out from the spruce "glades" except in areas where *Pinus strobus* was a significant component to the pine canopy. Mapped units of this association were generally small and scattered throughout the island, generally occurring on basaltic outcroppings.

- Mount Saginaw Jack Pine Stands

This region is significant in that it is the only portion of the island where *Pinus banksiana* is mapped over fairly extensive areas (approximately 700 acres in the general region). These stands often contain a continuous unbroken canopy of pine that may or may not be a co-dominant with *Picea mariana.* Mapped polygons become more fragmented and smaller to the west, generally ending west of Lake Whittlesey. Physiognomy becomes more variable in the smaller units, often with a more open canopy of pine and/or spruce.

- Siskiwit Basin Region

The Siskiwit Basin is a large east-west trending wetland complex that extends from Feldtmann Lake to the western shores of the Siskiwit Bay. It is approximately seven miles long and one to two miles wide in its north-south extent. Although wetland communities with a highly variable physiognomy occur throughout Isle Royale National Park, nowhere is this so evident over such a concentrated area as in the Siskiwit Basin. These wetland communities usually express themselves as sedge meadows with or without a sphagnum layer, bogs and fens containing ericaceous shrubs, or swamps with a sparse to dense canopy of spruce, larch and/or cedar. This is the only part of the island where *Larix laricina* occurs in significant enough stands to form a *community (Larix laricina* / *Alnus incana* Forest Association). The most extensive uninterrupted canopy layer of cedar swamp types also occurs within this region. Just south of the Siskiwit Basin, a narrow but extensive north facing cliff supporting a sparse cliff forest community that can be observed from the Feldtmann Ridge Trail.

- Offshore Islands (including Passage Island)

Much of the offshore islands support vegetation communities containing a number of stunted (krummholz) trees and shrubs. Several communities on these islands are described only on Passage Island and may receive high global rankings based on further study. In general, most units mapped on the offshore islands are based only on plot data. No PI signature correlation has been established for a number of the small island associations.

III. SUMMARY OF THE MAPPING EFFORT

The following section outlines in chronological order the vegetation mapping effort at Isle Royale National Park. For a detailed description of the tasks listed below, refer to sections IV and V.

June 1996
- Initial project planning meeting held at Isle Royale National Park
- Received film for 1994 and 1996 CIR aerial photography

August 1996
- Received draft classification for Isle Royale from TNC
- Received 1994 and 1996 CIR aerial photographs
- Developed general flight line indexes for aerial photographs
- Received data files from Michigan Technical University (MTU) for fire history, vegetation and trails

September 1996
- AIS/TNC field reconnaissance trip

December 1996
- Preliminary PI completed

January 1997
- Question polygon map sheets and sample photo overlays sent to TNC
- Preliminary PI key and field reconnaissance trip report sent to ESRI

June 1997
- Copies of all preliminary PI photo overlays delivered to TNC

September 1997
- TNC field sampling completed

April 1998
- Received TNC plot data
- Received 41 DOQQ files
- TNC/AIS classification crosswalk meeting
- Received TNC preliminary classification listing

May 1998
- Reviewed photointerpretations based on plot data, crosswalk, classification

June 1998
- Submitted classification question forms to TNC
- Delivered revised PI overlays to TNC for accuracy assessment task

July 1998
- USGS corrected two DOQQ files that did not meet standards

August 1998
- TNC finished collecting accuracy assessment point locations and data
- Plotted 22 DOQQ base maps

October 1998
- Manual rectification of vegetation map units to DOQQ base plots done

December 1998
- Delivered Sugar Mountain S pilot module to NPS
- Completed manuscript task
- Delivered manuscripts to ESRI for scanning

January 1999
- Received revised TNC classification and key

February 1999
- Received and checked edit plots for PI types, height and density attributes
- Received revised preliminary TNC classification and key

March 1999
- ESRI performed edit plot corrections and returned 22 export coverages

August 1999
- Received final TNC classification, key and descriptions

February 2000
- Completed digital rectification

June 2000
- Crosswalk and classification finalized
- Final documentation completed
- Delivery of coverage to ESRI

IV. VEGETATION MAPPING

One of the most important mandates of the Vegetation Mapping Program is the consistent capture and classification of vegetation types through PI and field sampling methods. Mapping criteria and procedures developed during the prototype parks are currently being tested and revised.

The first two parks mapped - Assateague Island National Seashore and Tuzigoot National Monument utilized a vegetation layer mapping approach. Layer mapping consists of PI of multiple canopies of vegetation that are visible on the aerial photography. Canopies are normally defined by the structure of the vegetation (trees, shrubs, or herbaceous growth). Where possible, individual plant species are interpreted for each layer of vegetation. These data layers are then aggregated up into the appropriate alliance or community as defined by TNC. Subsequent parks, including the Nebraska grassland parks, Rock Creek Park, and Congaree Swamp National Monument, involved mapping an initial photo signature type describing multiple vegetation canopies. These photo signature types are then translated into a TNC community type or alliance. Height, density and pattern are additionally assigned to each polygon. PI signature types are retained to further describe at a more detailed level the attributes visible on the aerial photography for each polygon.

Initial Project Planning Meeting

Meetings were held June 20-21, 1996 at Isle Royale National Park (ISRO) to bring together the project team members from the National Park Service, ESRI, AIS, TNC, and MTU. Participants of the meeting included: Maury Nyquist – NBS/TTC, Jack Oelfke – NPS/ISRO, Dave Soleim – NPS/ISRO, Tony Curtis – ESRI, Denise L. Cline – AIS, Jim Drake – TNC, Will MacKinnan – Michigan Heritage, Mike Hyslop – MTU, and Bob Janke – MTU. These meetings focused primarily on discussing the Vegetation Inventory and Mapping Program, existing park data, logistics, and park specific issues.

During the meetings, imagery, basemaps, and other pertinent collateral materials were reviewed and evaluated. It was noted that Michigan Technical University supports the Park by maintaining the digital data layers for Isle Royale. Included in this inventory were the following data items:

- <u>Vegetation/Fuel Type Mapping of Isle Royale National Park</u>, Steigerwaldt, W. and M. Meyer, Remote Sensing Applications in Agriculture and Forestry, IAFJE RSL Research Report 79-1, June 1, 1979.
- <u>Vegetation Type Map of Isle Royale National Park</u>, L.W. Krefting, H.L. Hansen and M.P. Meyer, U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, Denver, Colorado, 1970.
- <u>National Wetlands Inventory</u>, hardcopy format, scale 1:80,000
- SCS soil series data, digital format, scale 1:15,840
- General geology, digital format
- Fire history data, digital format, point locations

- Research projects on Isle Royale:
  - Janice Glein, moose and liverwort
  - Bob Janke, post-fire revegetation
  - Peter A. Jordan, wolf studies, GPS plots
  - Emmet J. Judziewicz, sensitive plant surveys
  - Rolf Peterson, moose studies
  - Bob Stottlemeyer, Wallace Lake

The logistics for fieldwork on Isle Royale National Park were discussed as part of the project strategy. The two factors that impact the logistical planning at the Park are the relatively short time that Isle Royale is open to visitors and the limited access on the island. First, field work could only be conducted during a five month period from late spring to early fall (mid-May to mid-October). Secondly, due to the wilderness nature of the Park, transportation is limited to hiking or boat travel. The Park was able to provide limited support in the form of boat transport or lodging (Davidson Island) for the field crews, consequently hiking and backpacking with overnight camping was the primary mode of accessing the Park. The Isle Royale National Park staff emphasized the need for flexibility for field reconnaissance and field sampling teams due to the unpredictability of weather conditions.

Development of Photointerpretation Mapping Procedures

The normal process in vegetation mapping is to conduct an initial field reconnaissance, map the vegetation units through photointerpretation, and then conduct field verification. The field reconnaissance visit serves two major functions.

First, the photointerpreter keys the signature on the aerial photos to the vegetation on the ground at each signature site. Second, the photointerpreter becomes familiar with the flora, vegetation communities and local ecology that occur in the study area. Park and/or TNC field biologists that are familiar with the local vegetation and ecology of the park are present to help the photointerpreter understand these elements and their relationship with the geography of the park.

Upon completion of the field reconnaissance, photo interpreters delineate vegetation units on mylar sheets that overlay the 9”x9” aerial photographs. This effort is conducted in accordance with the TNC vegetation classification and criteria for defining each community or alliance. The initial mapping is then followed by a field verification session, designed to confirm that the vegetation units were mapped correctly. Any photointerpretation related questions are also addressed during the visit.

The vegetation mapping at Isle Royale National Park did not follow the normal mapping procedure as outlined above. Because of logistical limitations (short field season, overall general inaccessibility and difficulty in reaching a large number of photo signatures within a relatively short period of time), field verification was not conducted on the island. In lieu of field verification, a TNC ecologist would meet with the photointerpreters at AIS to review the delineations and PI signature calls as they relate to the preliminary classification. (See page 13 – TNC/AIS Classification Crosswalk Meeting). The photointerpreters would also provide the ecologist with photo overlays identifying polygons with PI questions and polygons for verification that the ecologist could answer in the field while conducting the classification field sampling.

Development of Photointerpretation Mapping Criteria

From the onset of the Vegetation Inventory and Mapping Program, a standardized program-wide mapping criterion has been used. The mapping criterion contains a set of documented working decision rules used to facilitate the maintenance of accuracy and consistency of the PI. This criterion assists the user in understanding the characteristics, definition and context for each vegetation community.

Additional criteria specific to mapping at Isle Royale National Park is described in the following three sections:

Park Specific Mapping Criteria

During the initial planning meeting, Park staff discussed the need for an accurate vegetation map to assist in fire management programs and in locating sensitive habitats. Of particular interest would be the detailed mapping of white pine on the ridgetops, identifying dead paper birch trees affected by plant diseases, and delineating narrow bands of sensitive nonforested habitats along the rock lake shorelines. After review of the available aerial photography, it was determined that the white pine and nonforested shoreline issues could be addressed. The representation of these map units would be limited by the minimum mapping resolution (1/2 hectare). Dead paper birch stands were not evident on the existing 1996 aerial photography.

TNC Classification, Key, and Descriptions

The assignment of alliance and community associations to the vegetation is based on criteria formulated by TNC. TNC provided AIS with a tentative mapping community classification in August 1996. This classification was used as the basis in developing a PI signature type listing used during the preliminary photointerpretation task. Plot sample data collected by TNC for most of the types were also used to gain insight on how the community types were developed in the Park. A final vegetation classification, key, and descriptions were completed in August 1999.

Working Photo Signature Key

A photo signature key is an important tool for maintaining consistency in PI. The key correlates the physical descriptions of the photo signature with the appropriate vegetation community. A key may also describe other useful information that would be helpful in the interpretation. For Isle Royale National Park, a preliminary, or working, photo signature key was developed during the initial mapping phase. The key was used to identify and label the photo signature map units.

Field data collected during the reconnaissance effort were analyzed and compared with the aerial photos and a consistent correlation between the photo signatures and vegetation types were noted. Each photo signature was then assigned a generalized vegetation type based on the preliminary vegetation listing for the Park. As the classification was further developed, this photo signature key was later modified to accommodate the final classification.

The final photo signature key is in a table format, and contains the TNC project code and community name, photo signature code and name, photo signature characteristics (color, crown size, crown shape, texture), context/notes, and mapping status.

Project Set-Up

A complete set of aerial photography was provided for the project with the following specifications:

- Color infrared photography (CIR)
- Flight date - spring 1996 (leaf off – transitional to leaf flush)
- Nominal scale – 1:15,840
- Approximate photo size – 9” x 9”
- Prints and diapositives

A supplemental set of aerial photography was provided to assist in labeling community types for the gap areas in the 1996 flight lines. The specifications for this set of aerial photography are listed below:

- Color infrared photography (CIR)
- Flight date -fall 1994 (leaf on)
- Nominal scale – 1:15,840
- Approximate photo size – 9” x 9”
- Prints and diapositives

A general flight line index was created for each set of photography. See Figure IV.1 1996 Photo Index and Figure IV.2 1994 Photo Index. These indexes were used for quick reference to photo locations and as a status tool showing work completed on various portions of the project.

Field Reconnaissance Preparation

Prior to the field reconnaissance, several in-house preparations were performed in order to facilitate a more organized trip. The island was split into an eastern and a western region for the field reconnaissance effort. Field itineraries were planned for two field teams based on this split. Due to access limitations and the size of the island, photos were selected within close proximity to trails. Each selected photo was prepared with a frosted mylar field overlay. Locational features (trails and place names) were delineated on the overlays for reference.

Each photo was reviewed under a stereoscope to choose field transect sites representing different signatures types, geographic variables (% slope, aspect, shape of the slope, elevation), and other abiotic variables noted on the photography. PI check sites and associated notations were also drafted onto the field overlays. Multiple sites were chosen to provide alternatives if one or more sites proved inaccessible.

The field photographs (CIR prints), overlays and associated topographic sheets were arranged in packets for the field teams. Alternative sets of photos were also prepared to allow the teams flexibility if logistical problems arose.

Field Reconnaissance Trip

A seven-day PI field reconnaissance effort was conducted in September 1996 to establish relationships between the photo signatures evident on the aerial photographs and habitats on the ground. The field team members were: Lisa Cotterman – AIS, Jim Drake – TNC, Will MacKinnan – TNC and John Menke – AIS.

The field crews conducted on-site investigations backpacking throughout the island over the seven-day period. The teams started at separate ends of the island at Windigo and Tobin Harbor (near Rock Harbor) to maximize coverage of the Park. During the field visit, the photointerpreter worked with the field biologists to identify the plant species, preliminary vegetation communities, and the associated photo signature.

Field site numbers were annotated directly onto the photo field overlay, thereby correlating the field site to a specific location and photo signature. A field notebook was used to record pertinent information (canopy dominance, understory species present, abiotic features, disturbance history) for each site visited. Several ground photos (35mm) were taken at selected locations and later compared to the aerial photographs and the field site notes. Areas not previously identified on the aerial photos were also visited. These sites included areas in transit, particularly those between initially selected sites, areas of noteworthy or unusual significance, and other areas the photointerpreter or ecologist deemed important.

The two field crews hiked approximately 70 percent of the major trails on the island viewing a range of the island's major vegetation types. Several areas of the Park were not visited including: the western portions of the Minong Ridge trail, part of the Greenstone Ridge trail (between Island Mine and Ishpeming Point), Saginaw Point, and Passage Island. It was noted that three major forest types classify most of the forested vegetation types observed: boreal forests (spruce/fir, aspen/paper birch), northern hardwood forests (sugar maple, yellow birch), and wetland forests (cedar, black spruce).

Photointerpretation of Vegetation

PI is the process of identifying map units based on their photo signature. All land cover features have a photo signature. These signatures are defined by the color, texture, tone and pattern they represent on the aerial photography. By observing the context and extent of the photo signatures associated with specific vegetation types, the photointerpreter is able to identify and delineate the boundaries between plant communities or signature units. Additional collateral sources (existing vegetation maps, supplemental photography, soil data, etc.) can be of great utility to the photointerpreter. Understanding the relationship between the vegetation and the context in which they appear is useful in the interpretation process. Familiarity with regional differences also aids interpretation by establishing a context for a specific area.

A total of 240 photos were needed to provide full photo coverage of the study area. Due to the inconsistent spacing between flight lines and the rough terrain of the Park, it was determined that PI delineations would be done on every photograph.

Each photo was prepared with a 9"x9" frosted mylar overlay for the photo signature delineations. Photo overlays were then pin-registered to the photos and project labels were affixed to each overlay identifying the photo number, status of work, and photo interpreter responsible for that task. Study area boundaries were drafted onto each photo overlay, defining the area within the photograph to be interpreted. The study area boundaries were edge matched to adjacent photos to ensure complete coverage.

Using a mirror stereoscope, with a 3X lens, photo signature units were delineated onto the mylar overlays. These initial photo delineations were based on a number of \signature characteristics including color, tone, texture, relative height and density. Attribute codes (photo signature types, height and density) were assigned to each polygon. The photo signature map units and codes were edge matched to the adjoining photo overlays.

PI of vegetation traditionally takes place after the vegetation classification has been developed. For Isle Royale National Park, the classification existed in a draft form. Additional field samples were required by the biologists to verify and describe the potential communities that were on the draft classification. The additional field samples also helped described several new communities previously not sampled on the island. In order to assist the TNC field crews in their effort, AIS completed the photointerpretation of the vegetation using the draft classification as a guide, adding new photo signature units that did not fit into any of the existing TNC draft types.

In order to assist the photointerpreters in correlating signatures to the environment and help address problem signature types, selected polygons were identified on the aerial photography and then transferred to enlargements of the USGS topographic 1:24,000 map sheets. These maps were provided to TNC field ecologists for use in conjunction with their field effort.

As the vegetation types were being photointerpreted areas of land use were also interpreted, delineated, and coded onto the photo overlay.

Photointerpretation Field Verification

A field verification trip was not conducted for this mapping effort. See page 10, (Development of Photointerpretation Mapping Procedures).

TNC/AIS Classification Crosswalk Meeting

A three-day classification meeting was held at AIS in April 1998. An intensive review of the vegetation classification, PI signature types, and plot data resulted in the development of a preliminary crosswalk linking the PI photo signature types to the TNC community types. Several of the preliminary TNC communities were combined into one community, some were re-categorized under a different alliance and several were deleted from the draft list. PI signature types were also reviewed with the TNC ecologist; this helped in establishing the relationship (crosswalk) between the PI signatures and TNC communities.

The vegetation classification for Isle Royale National Park was not complete at the time of the crosswalk meeting. The classification was later revised by TNC based on new information gathered by the TNC field team during the accuracy assessment task. The crosswalk was revised to accommodate the classification changes.

Final Photointerpretation

After the classification crosswalk meeting, AIS proceeded with applying final revisions to the PI linework and photo signature typing. The TNC plot locations were drafted onto the corresponding aerial photo PI overlay for reference. Each polygon was reviewed with consideration of the field sampling plot data, classification and the information gathered during the classification discussions. Any uncertain interpretations were flagged on the mylar overlays for review during the quality control task.

Photo overlay edges were reviewed to the adjacent photo delineations to ensure a seamless coverage in the database. Delineations and codes were compared and discrepancies between photos were resolved and corrected on the mylar overlays.

Quality Control of the Photointerpretation

A separate quality control step was performed for each photo upon completion of the PI. A senior photointerpreter reviewed each photo for map unit delineation, PI signature code, height code, and density code accuracy. Each photo overlay was checked for completeness, consistency, and adherence to the mapping criteria and guidelines. For those polygons flagged by the photointerpreter, the quality control reviewer assigned the appropriate vegetation code and discussed the situation with the interpreter.

Final Reviews of the PI Signature Key

After the PI and geo-referencing of the polygon data was complete, a final review of the signature key and how it cross-walked to the TNC communities was implemented through discussions by TNC ecologists and AIS photointerpreters. An additional column to the PI Signature Key was added to address the mapping status of each TNC community. The column defined each community based on the following:

1. Mapped: The photo signature name can be tied to a TNC community using the photo signature and bio-physical relationships.
2. Not Mapped MMU: The photo signature may or may not be visible on the aerial photography and a community – signature relationship may or may not exist, however, the TNC Community is distributed over the island in units too small to map.
3. Alliance: The TNC community(s) is beyond the resolution of the aerial photography, and or bio-physical relationships cannot be reliably established to the community level and therefore must be aggregated up to an alliance level.
4. Complex: The TNC community(s) is beyond the resolution of the aerial photography, and or bio-physical relationships cannot be reliably established to the community or alliance level and therefore must be aggregated up to a complex level.
5. Variant: The TNC community is further divided up into one or more variants based on physiognomic characteristics (canopy density) and can be identified and mapped on the aerial photography.
6. Mosaic: Two or more TNC communities occur in units that are generally below the MMU and are therefore aggregated into one polygon.

V. DATA CONVERSION

Basemap Production

In order to begin the data conversion process, a hardcopy version of the base was needed. The designated base was the USGS digital orthophoto quarter quads (DOQQ) series. The 41 DOQQ files for Isle Royale were standard black and white USGS products made from 1992 1:40,000 scale NAPP photography.

Creation of the DOQQ base plots required having the images plotted onto clear mylar at the same scale as the aerial photographs, approximately 1:15,840. To minimize the number of map sheets, two DOQQ images were plotted together so that each plot represented one half of a USGS topographic quadrangle map. A total of 22 mylar base plots were generated using a Hewlett Packard 755CM plotter.

Manual Rectification

Manual rectification was conducted by attaching a new frosted mylar overlay to each base. The photo signature delineations were transferred to the overlays through local registration of each photo with its photo signature overlay to the base. By matching photo image to orthophoto image, the delineations were transferred to the base overlay. Because the parallax of the photo differs from that of the orthophoto base, care was required in transfer. Inconsistent stretching or shortening of the images was common from the photo to the base. When one area was completed, the photo was shifted to register to another small area. The process continued until the manual rectification and transfer of polygons was complete.

Due to the difference in dates between the CIR aerial photography (1996) and the DOQQ (1992) there were significant differences in the land/water interfaces for the inland lakes. The 1992 images represented much drier conditions. Since the DOQQ was the project base, the lake boundaries were adjusted to match the water as depicted on the DOQQ image.

The three code attributes (PI signature code, height code, and density code) were also transferred from the photo overlays. Each rectified map sheet was edge matched to the adjacent sheet. To guarantee accuracy of the rectification, delineation, and transfer of attributes, a quality control step was performed by a senior photointerpreter.

DOQQ Edge Problems

While rectifying the delineations to the DOQQ's, spatial discrepancies between the quarter quad images were noted. In addition, it was determined that this "data shift" did not occur on a consistent basis across module boundaries. Adjacent DOQQ images were shifted as much as 1/4" when plotted at the 1:15,840 scale. See Figure V.1 for the DOQQ Index depicting the DOQQ coverage and edges with significant edgematch problems. Data shifts from 5 to 50 meters were noted between various DOQQ images within the study area.

Manuscript Map Preparation

Twenty-two manuscript maps, suitable for automation, were created to input the spatial component of the vegetation mapping units. The manuscripts were produced by pinregistering a clean sheet of mylar to the hardcopy DOQQ base. The vegetation delineations from the manually rectified overlays were transferred to the new overlays using black P2 Pentel lead. The manuscript maps were carefully edited to ensure completeness and correctness. The editing included comparing the manuscripts with the original delineations on the aerial photos and edge matching of all manuscripts.

Quality Assurance of the Manuscript Maps

The final manuscript maps underwent a quality assurance review. The manuscript maps were compared to geo-referenced (rectified) overlays to ensure that all of the map units were transferred correctly. Particular attention was given to the quality of the line delineations with respect to gaps and other irregularities to guarantee that each map sheet met scanning standards.

Sequence Number Assignment

Sequential identification number overlays were produced for each manuscript maps. A sheet of mylar was pin-registered to each manuscript, and each polygon was labeled with a unique sequence number. These sequence number identifiers were used to tie the spatial files to the keypunched attribute files.

Polygon Attribute Encoding

To expedite the encoding of the vegetation attributes for each polygon, a Microsoft Excel spreadsheet file was created for each sheet. A separate field was created for the polygon sequence number, map sheet name, PI signature type, height, density and land use code attributes. The manuscript maps, sequence number overlays and attribute overlays were pin-registered together on a light table. The technician followed the numbers on the sequence number overlays and key-entered the vegetation attributes for each polygon. During this task, the accuracy of the sequence number labels was checked. Any errors found on the sequence number overlay were corrected to ensure that each polygon had a unique identifier.

Spatial Data Input/Scanning

The manuscript maps were scanned and converted into ARC/INFO coverages by ESRI. Prior to any production scanning, test scans of small areas of the data map were conducted to determine the optimum raster to vector conversion settings. The critical settings that determine the output resolution and completeness are the TOLERANCE and THRESHOLD. The TOLERANCE, which governs the output resolution and is comparable to fuzzy tolerance, would be set to .01 inches (10 feet at 1:12,000 scale). The THRESHOLD is a reflectance measure. It is dependent on the physical characteristics of the data maps and their contents and is determined through testing. Once the THRESHOLD was derived, production scanning of manuscript maps began.

Assigning Polygon Identifiers

The polygon identification numbers were sequenced 1 through "n" (5-digit item width) on the sequence number overlays. In order to link the polygon attribute files with the spatial data, the sequence numbers for each polygon were digitized as a label point. The manuscript maps and the sequence number overlays were registered together on the digitizing board. The polygon identifiers were sequentially input. To ensure that all labels points were entered, the processor marked off each sequence number as it was digitized.

Creation of Topology

Topology is the mathematical procedure for explicitly defining spatial relationships. In the case of maps, topology defines connections between features, identifies adjacent polygons, and can define one feature such as an area, as a set of other feature types (i.e., lines). A topological database has several advantages: efficient data storage, faster processing, and the ability to perform analysis, such as modeling transportation networks or overlaying geographic features on one another.

Once the manuscript map's polygon boundaries and label points had been input into the computer, the ARC/INFO software CLEAN command was used to create the "coverage topology." The CLEAN fuzzy tolerance was set to .002 inches to preserve the required data resolution. When other coordinate edits were made to a coverage after the CLEAN command was run, topology was recreated utilizing the BUILD command.

Label Entry Error Processing

Label errors were identified by using the LABELERRORS command in ARC. Using ARCEDIT, any label errors identified were corrected by entering the missing label number and placing it within the correct polygon. Once all the errors were corrected, the coverages were joined with the attribute files.

Joining of Attribute and Spatial Data

The Excel code file was converted into an INFO file. Once converted it was related to the feature attribute table by the sequence number found in both files. An INFO item, named "SEQNO" was added to the feature attribute table. The sequence number for each polygon was calculated to equal its coverage ID number. The ARC/INFO command JOINITEM was used to join the code file to the feature attribute table. The spreadsheet file was joined with its corresponding coverage. Each variable interpreted from the aerial photography was assigned a unique item (field).

Code Verification and Edit Plot Quality Assurance

ESRI produced a plot of the converted spatial data and sequence numbers (label ID) for each manuscript. The plot was checked by AIS for cartographic quality of the arcs defining the polygon features and the accuracy of the label ID assignments. The plots were overlaid to the manuscript maps to verify that the scanned data was not distorted beyond .02 map inches. Other problems were noted on the plots, including lines which did not connect (undershoots) or went slightly beyond the adjoining line (overshoots), missing lines, premature convergence of polygon boundary lines that intersected arcs at acute angles, and incorrect sequence number assignments.

ESRI also produced code verification plots of height, density, and land use code attributes. The plots were checked by AIS for coding errors that may have occurred during the polygon attribute encoding step. The plots were overlaid on the corresponding manual rectification code attribute overlay. Code changes were noted on the plot. All plots were edgematched to verify line and code accuracy across map sheets. Codefind and code frequency programs were run to check for invalid codes. The edited plots were delivered back to ESRI for correction of the attribute files. Processors conducted interactive ARCEDIT sessions to make the necessary corrections to the coverages

Georeferencing of Data

This task involved the transformation of the database from "digitizer inches" into "real world" coordinates. The initial vector file contained coordinates stored as digitizer inches. This format does not allow the data to be used in conjunction with other spatial overlays. To utilize geographic data, it must be converted into a common coordinate system. The coordinate system used is a UTM grid base Datum NAD83.

The first step was the creation of a master tic file, linking features on the orthophoto to the same features in the polygon coverages. Wherever possible, easily identified points were chosen to ensure a more accurate transformation. Four to six points were chosen per coverage and labeled with a tic number ID. The points were then transformed into real world coordinates, x and y values only (the orthophotos did not have a z value).

On-Screen Digital Rectification

A digital rectification procedure was conducted in an interactive ArcView (Version 3.1) session to register the scanned map units more accurately to the DOQQ. A specialized program was developed to view the digital orthophoto, the scanned polygonal boundaries, vegetation attributes and the arc revisions simultaneously. Each map unit was systematically checked and any shifted boundaries were refined to more closely fit the DOQQ image.

An edge match program highlighted any inconsistencies between the map sheets. Along edges with DOQQ data shift problems (See Figure V.1 DOQQ Index), the vegetation polygons were adjusted to create a seamless coverage. Typically these adjustments required an “averaging” of the error between the images. Consequently, map units within the vicinity of the DOQQ image data shifts cannot be considered spatially accurate.

After the digital rectification procedures were finished, the twenty-two individual module coverages were combined into one complete coverage for the Park. A final automated edgematch check was performed. An automated QC Codefind and a frequency program were run to review the code attribute accuracy.

Vegetation Code Crosswalk

The final TNC classification for Isle Royale National Park listed 60 alliance/community types. Some of these types were not evident on the available aerial photography and are listed as “Photo interpretation signature not established” in the Photointerpretive Signature Key. Approximately 53 photo interpretation (PI) signature types were recognized. Most of these PI types were aggregated into the TNC community types. The photo interpretation identified five signature types that did not crosswalk into the current classification, resulting in the creation of TNC project codes: **100** = Wooded peatland complex, **200** = Black ash (white cedar) – mixed hardwoods swamp complex, and **300** = White spruce woodland alliance. The revised PI code to TNC code vegetation crosswalk (see Photointerpretive Signature Key) was input into a Microsoft Excel file. The PI codes were translated into the final TNC project codes to populate the TNC community type field in the database.

Final Quality Assurance of the Vegetation Map

Once the crosswalk to the alliance/community classes was completed and the attribute items populated, a final vegetation community plot was created. The plot was reviewed for accuracy and consistency of community class assignments.

Pattern Assignment

The final community type plot was also used as a base to delineate the pattern types for the Park. The pattern variable describes the general distribution of the vegetation across the landscape. Pattern of vegetation can reflect the landform, soil, geology, climatic gradients, and/or elevational gradients. The minimum mapping unit (mmu) size for pattern assignment was 10 acres. The pattern types were input as a separate variable into the Isle Royale database. The completed coverage was delivered to ESRI to be converted into the final GIS format.

VI. DATA DICTIONARY – ISLE ROYALE NATIONAL PARK

A. DATA FORMAT OUTLINE:

Coverage related variables:

Area	8	18	F
Perimeter	8	18	F
Veg#	4	5	B
Veg-id	4	5	B

Defined variables:

Seqno	5	5	I
Mod8	6	6	C
PI	3	3	C
TNC	3	3	C
Height	1	1	I
Density	1	1	I
Landuse	3	3	I
Pattern	1	1	I

B. DATA DICTIONARY:

SEQNO (Defines AIS internal sequence number)

MOD (Defines the module name abbreviation, corresponds generally to the north or south half of a USGS topographic quad sheet)

BEHA-S	Belle Harbor – south
FELA-N	Feldtmann Lake – north
FERI-N	Feldtmann Ridge – north
LARI-N	Lake Richie – north
LARI-S	Lake Richie – south
LITO-S	Little Todd Harbor - south
MABA-N	Malone Bay – north
MABA-S	Malone Bay – south
MCCO-S	McCargoe Cove – south
MOIS-N	Mott Island – north
MOIS-S	Mott Island – south
PAIS-N	Passage Island – north
POHO-N	Point Houghton – north
POHO-S	Point Houghton – south
ROHA-N	Rock Harbor – north
ROHA-S	Rock Harbor – south
SUMO-N	Sugar Mountain – north
SUMO-S	Sugar Mountain – south
TOHA-N	Todd Harbor – north
TOHA-S	Todd Harbor – south
WIND-N	Windigo – north
WIND-S	Windigo - south

PI (Defines the PI signature number and name)

1	Jack pine – black spruce / feathermoss forest (forest phase)
2	Spruce – fir / feathermoss forest
3	White cedar – boreal conifer mesic forest
4	White cedar – (mixed conifer) / alder swamp (open phase)
5	Black spruce / dwarf-shrub swamp complex
6	White cedar – (mixed conifer) / alder swamp (closed phase)
8	Maple – yellow birch – northern hardwoods forest (sugar maple phase)
9	Maple – yellow birch – northern hardwoods forest (mixed phase)
10A	Maple - yellow birch – northern hardwoods forest (yellow birch phase0
11	Red oak – sugar maple forest
12	Paper birch / bush honeysuckle - fir forest
13	Aspen – birch / boreal conifer forest (mixed aspen – birch phase)
15	Aspen – birch / sugar maple – mixed hardwoods forest (mixed phase)
16A	Aspen – birch / sugar maple – mixed hardwoods forest (aspen phase)
16B	Aspen – birch / boreal conifer forest (aspen phase)
16C	Aspen – red maple forest
17	Black ash – mixed hardwood swamp complex
17A	Black ash (cedar) – mixed hardwoods swamp complex
18	Northern tamarack rich swamp
19	Balsam fir / paper birch forest
19A	Balsam fir – aspen - paper birch forest
19B	Balsam fir / Canada yew – devil's club forest
20	White spruce – balsam fir – aspen forest
21	White cedar – yellow birch forest (cedar – birch phase)
22	Jack pine – black spruce / feathermoss forest (woodland phase)
23	White spruce woodland alliance
25	Aspen – birch / boreal conifer forest (sparse canopy phase)
25A	Aspen – red maple rocky woodland
26	Common juniper rocky krummholz
27	Boreal rocky shrubland
28	Speckled alder swamp
29	Dwarf shrub fen complex
30	Poverty grass barrens
31	Bluejoint eastern meadow
32	Sedge meadow complex
32A	Sedge / sphagnum meadow complex
49	Red maple – ash – birch swamp forest
50	Yellow birch – (spruce) forest
50A	White cedar - yellow birch forest (mixed phase)
51	Boreal pine rocky woodland
53	Aspen – birch / boreal conifer forest (woodland phase)
53A	Spruce – fir – aspen open forest
54	Spruce - fir and sugar maple – yellow birch mosaic
55	Aspen - birch / sugar maple – mixed hardwoods forest (paper birch phase)
56	White pine – aspen – birch forest

60	Northern (laurentian) igneous / metamorphic moist cliff scrub
61	Great Lakes bedrock lakeshore
63	Great Lakes cobble/gravel shore
65	Great Lakes non-alkaline cobble/gravel shore
67	Great Lakes bedrock lakeshore (undifferentiated bedrock)
67A	Great Lakes cobble/gravel lakeshore (undifferentiated gravel)
70	Balsam poplar – paper birch / speckled alder forest
71	Paper birch – white spruce – balsam fir forest
75	Mountain ash – mountain maple forest
83	White cedar – balsam fir / leatherleaf / black crowberry krummholz
88	Canada yew mixed shrubland
90	Balsam fir woodland
98	Water
99	Not applicable (urban/built-up)

TNC (Defines TNC project code and community common name)

1	Spruce – fir / feathermoss forest
2	Balsam fir / Canada yew – devil's club forest
3	White pine – aspen – birch forest
4	White cedar – boreal conifer mesic forest
5	Black spruce / feathermoss forest
6	Jack pine – black spruce / feathermoss forest
7	White cedar – (mixed conifer) / alder swamp
8	Aspen – birch – red maple forest
9	Maple – yellow birch – northern hardwoods forest
10	Red oak – sugar maple forest
12	Northern (laurentian) igneous / metamorphic moist cliff scrub
13	Mountain ash – mountain maple forest
14	Aspen – balsam poplar lowland forest
16	White cedar – yellow birch forest
18	White cedar – black ash swamp
19	White spruce woodland
22	Balsam fir / Canada yew woodland
23	Spruce – fir – aspen forest (open variant)
25	Black spruce / Labrador tea poor swamp
26	Black ash – mixed hardwood swamp
27	Red maple – ash – birch swamp forest
28	Great Lakes boreal talus woodland
29	Boreal rocky shrubland
31	Common juniper rocky krummholz
32	Thimbleberry shrubland
33	Great Lakes basalt/diabase cobble-gravel lakeshore, shrub zone
34	White cedar – balsam fir / leatherleaf / black crowberry krummholz
35	Canada yew mixed shrubland

36 Speckled alder swamp
37 Sweet gale shrub fen
38 Poverty grass barrens
39 Great Lakes basalt/diabase cobble-gravel lakeshore

40 Bluejoint eastern meadow
41 Northern sedge wet meadow
42 Northern poor fen
44 Boreal calcareous seepage fen
45 Great Lakes shoreline bulrush – cattail marsh
46 Midwest mixed emergent deep marsh
47 Water horsetail – spikerush marsh
48 Twig rush wet meadow
49 Midwest pondweed submerged aquatic wetland

50 Northern water lily aquatic wetland
51 Great Lakes basalt (conglomerate) bedrock lakeshore
52 Great Lakes basalt/diabase cliff
53 Paper birch / bush honeysuckle – fir forest
54a Aspen – birch / boreal conifer forest
54b Aspen – birch / sugar maple – mixed hardwoods forest
55 Spruce – fir – aspen forest
56 Spruce – fir and sugar maple – yellow birch mosaic
58 Sedge meadow complex
59 Sedge / sphagnum meadow complex

60 White cedar – sweet gale scrub fen
62 Spruce – fir basalt bedrock glade
63 Boreal pine rocky woodland
65 Northern tamarack rich swamp
66 Black spruce / alder rich swamp
67 Leatherleaf – sweet gale shore fen

70 Leatherleaf bog
72 Timothy – (bluejoint) seminatural meadow
74 Yellow birch – (spruce) forest

98 Water
99 Urban/Built-up

100 Wooded peatland complex
200 Black ash (white cedar) – mixed hardwoods swamp complex
300 White spruce woodland alliance

HEIGHT

1 = < 0.5 meters
2 = 0.5 – 2 meters
3 = 2 – 5 meters
4 = 5 – 15 meters
5 = 15 – 35 meters
6 = 35 – 50 meters

7 = > 50 meters
9 = Not Applicable

DENSITY

1 = Closed/Continuous	< 60%
2 = Discontinuous	40% - 60%
3 = Dispersed	25% - 40%
4 = Sparse	10% - 25%
5 = Rare	2% - 10%
9 = Not Applicable	

LANDUSE

100 = Urban/Built-up
200 = Agriculture
300 = Mining
400 = National Park Facilities
- **401** = Rock Harbor park facilities
- **402** = Windigo park facilities
- **403** = Mott Island park headquarter facilities
- **404** = Campground

800 = Water
900 = Vacant

C. FILE SPECIFICATIONS

Coordinate system: NAD83 UTM projection – Meters

APPENDICES

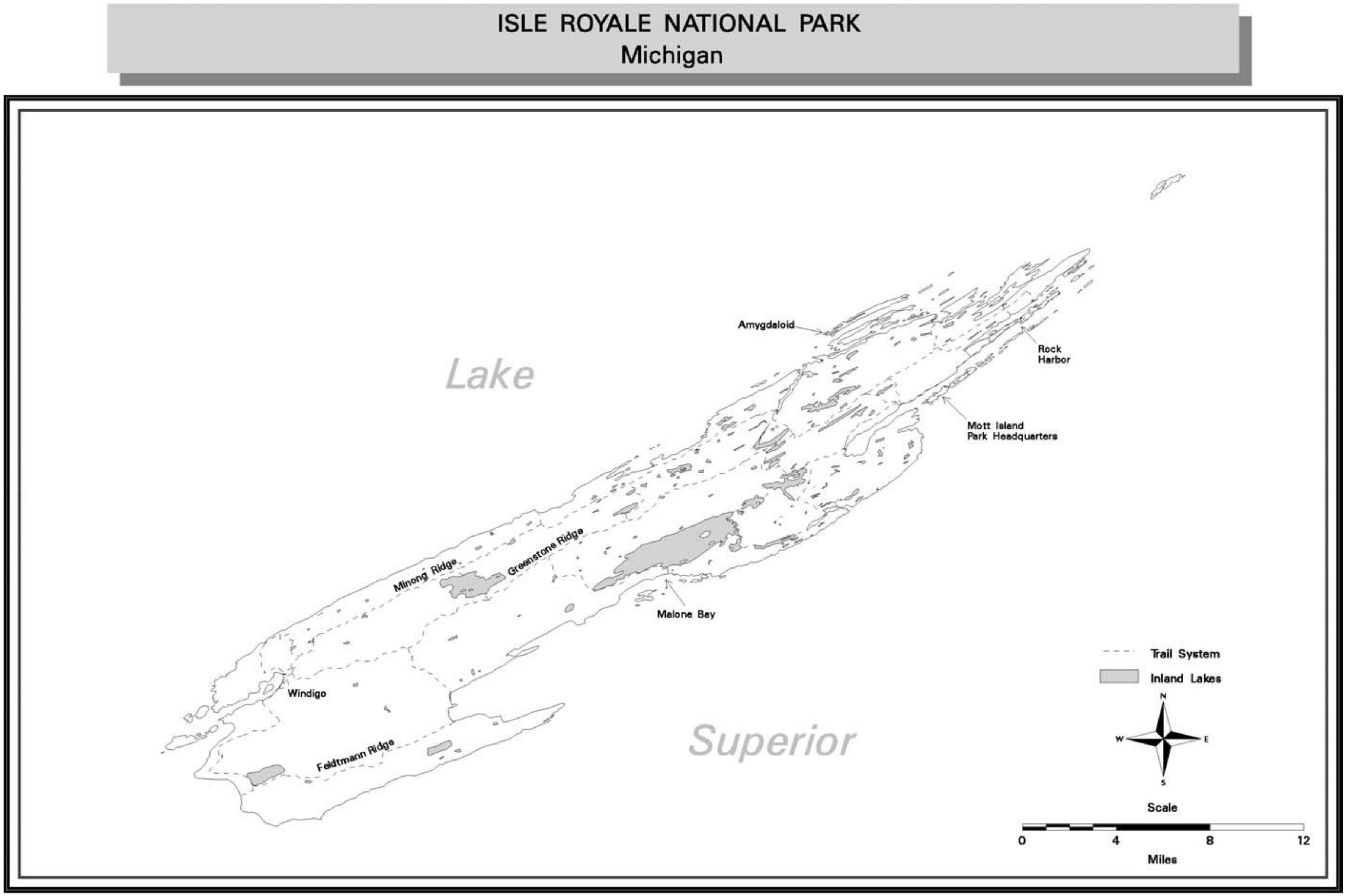

Figure II.1 -- Location Map

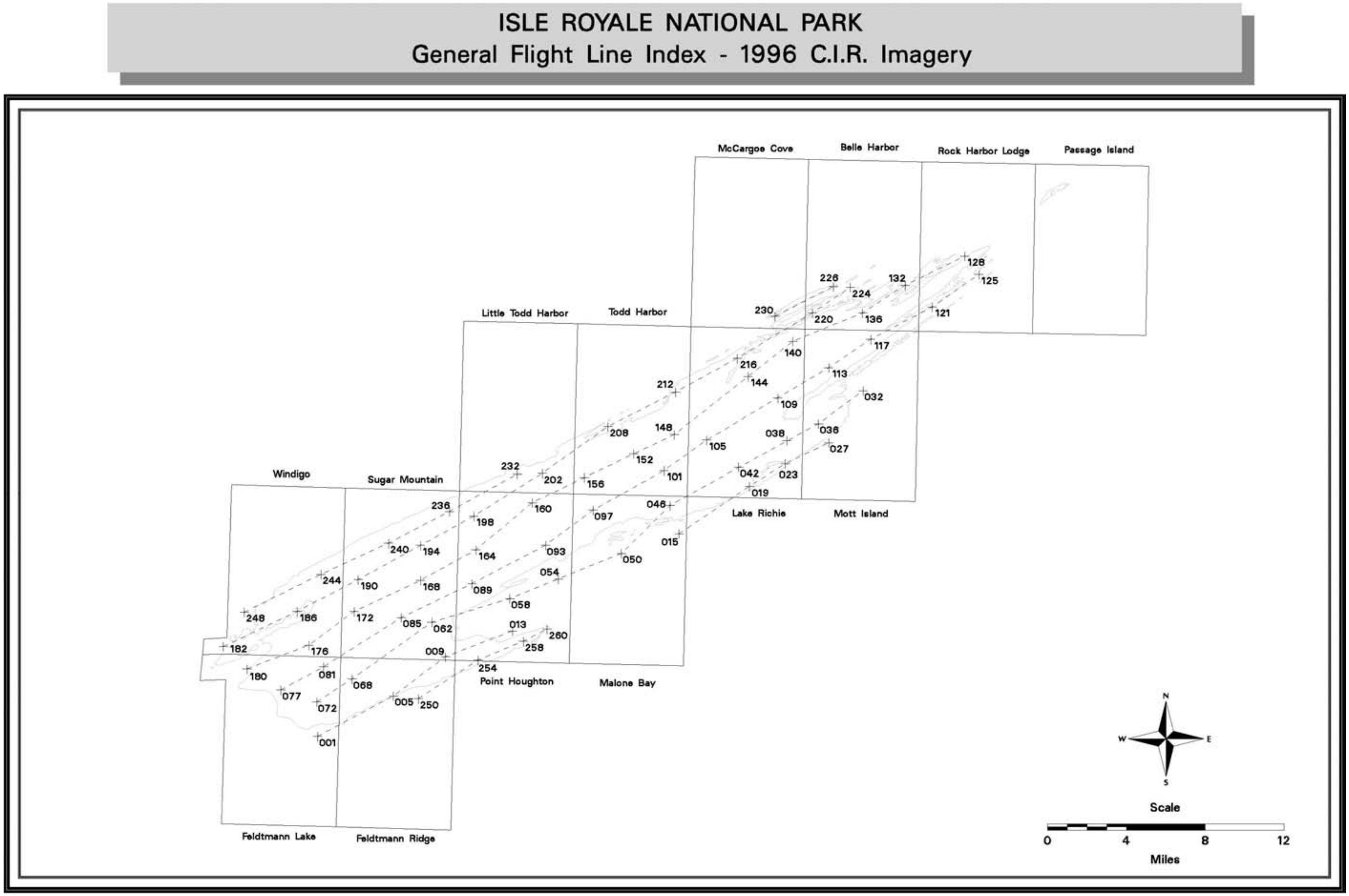

Figure IV.1 -- 1996 Photo Index

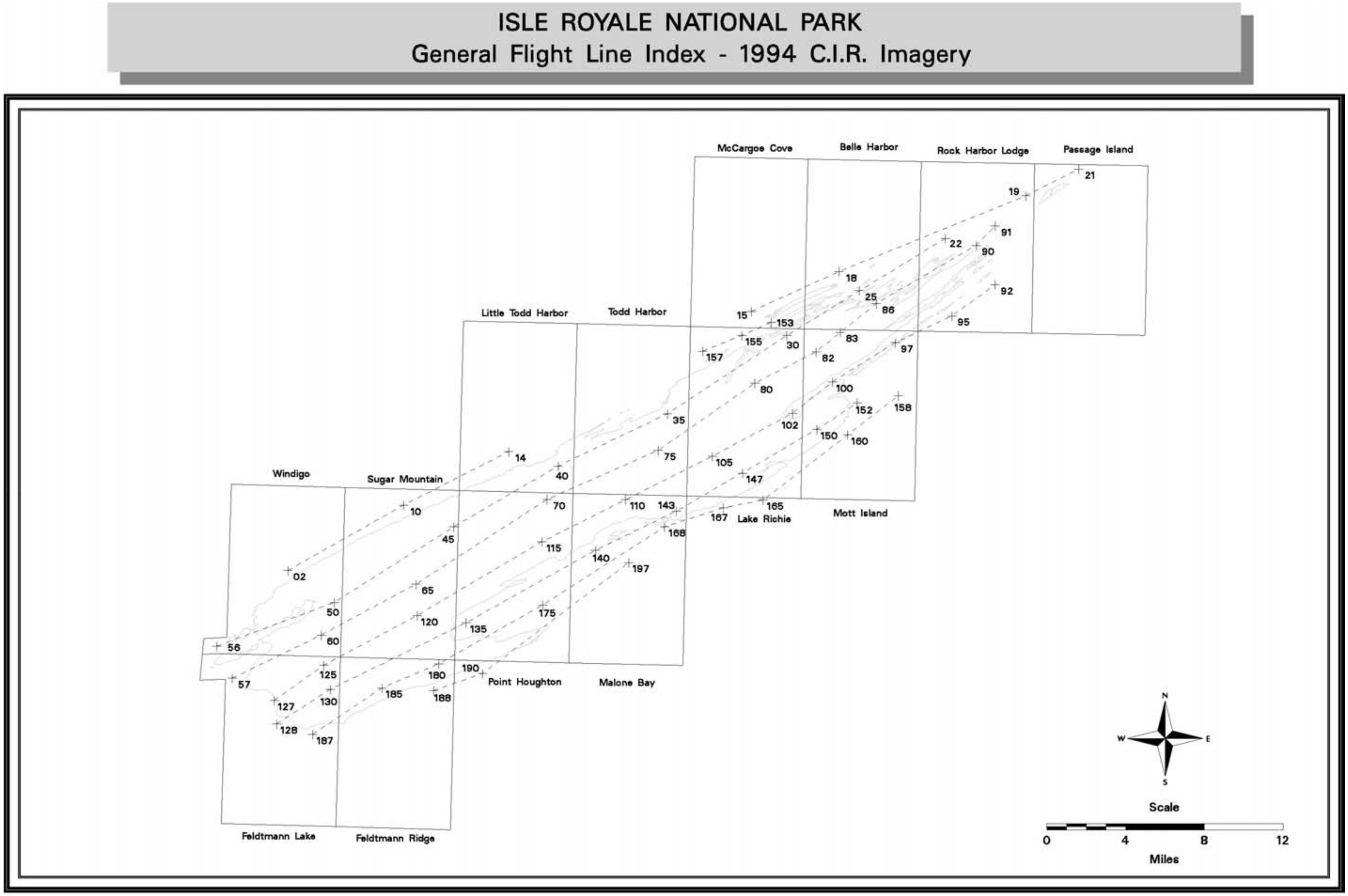

Figure IV.2 -- 1994 Photo Index

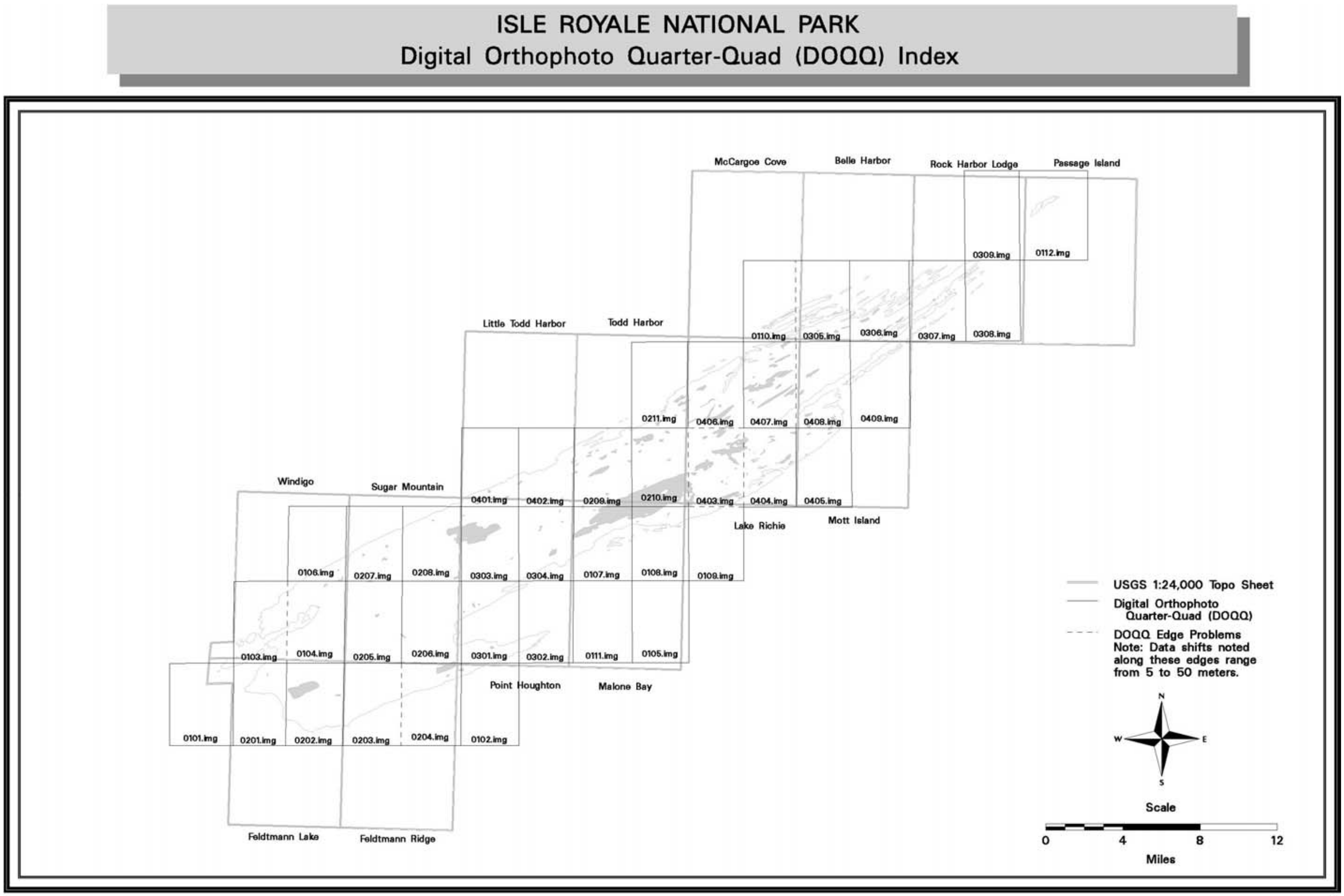

Figure V.1 -- DOQQ Index

TABLE 2.1 - UNITED STATES GEOLOGICAL SURVEY and NATIONAL PARK SERVICE VEGETATION INVENTORY AND MAPPING PROGRAM PHOTOINTERPRETIVE SIGNATURE KEY - ISLE ROYALE NATIONAL PARK, MICHIGAN

TNC Project Code	Community Common Name	PI Code	PI Signature Name	Photo Signature (1:15,840 CIR, May 1996)	Context/Notes	Mapping Status
01	Spruce - fir / feathermoss forest	**02**	Spruce – fir / feathermoss forest	**COLOR:** magenta **CROWN SIZE:** very narrow to medium **CROWN SHAPE:** conical **TEXTURE:** medium to fine	Mapped where the conifers are a strong component (>70-80%) of the canopy. Frequently observed at low elevations in mesic settings near the Lake Superior shore.	Mapped
		19	Balsam fir / paper birch forest	**COLOR:** magenta some gray **CROWN SIZE:** very narrow to medium **CROWN SHAPE:** mostly conical **TEXTURE:** medium	Mapped to the same association, however with a canopy or sub-canopy component of paper birch of typically under 25%, (occasionally more).	Mapped
02	Balsam fir / Canada yew - devil's club forest	**19B**	Balsam fir / Canada yew - devil's club forest	Photo Interpretation signature not established.	Mapped on Passage Island based only on plot information. No photo interpretation signature established.	Mapped
03	White pine - aspen - birch forest	**56**	White pine - aspen – birch forest	**COLOR:** red **CROWN SIZE:** large **CROWN SHAPE:** star like (spreading) **TEXTURE:** medium to coarse	Mapped as pure stands of white pine or with a significant component of aspen or paper birch up to approximately 40-50%.	Mapped
04	White cedar - boreal conifer mesic forest	**03**	White cedar - boreal conifer mesic forest	**COLOR:** dark magenta with some gray **CROWN SIZE:** medium **CROWN SHAPE:** conical **TEXTURE:** medium to fine	Generally mapped within close proximity to the Lake Superior shore in mesic north trending concavities. Polygons are generally fairly small size.	Mapped
05	Black spruce / feathermoss forest	**-**	-	Photo Interpretation signature not established.	Not mapped, no biophysical relationships established either in the field reconnaissance or subsequent plot data. Generally falls below minimum mapping unit (MMU).	Not mapped, MMU
06	Jack pine - black spruce / feathermoss forest	**01**	Jack pine – black spruce / feathermoss forest (forest phase)	**COLOR:** purple **CROWN SIZE:** medium **CROWN SHAPE:** rounded **TEXTURE:** medium fine	Large stands of Jack pine mapped south of the Moskey Basin in the Mount Saginaw region. Smaller stands locally mapped to the west.	Mapped
		22	Jack pine - black spruce / feathermoss forest (woodland phase)	**COLOR:** purple **CROWN SIZE:** medium **CROWN SHAPE:** rounded **TEXTURE:** medium to coarse	Mapped locally in the Mount Saginaw region and south of Lake Richie to Chippewa Lake. Different from above type in that the canopy cover is generally 40-60% absolute density.	Mapped
07	White cedar - (mixed conifer) / alder swamp	**06**	White cedar - (mixed conifer) / alder swamp (closed phase)	**COLOR:** orange **CROWN SIZE:** medium **CROWN SHAPE:** conical **TEXTURE:** medium to coarse	Mapped in wetland forest settings where canopy cover is greater than 60%. Found throughout the park at all elevations. Numerous stands contained dead cedar.	Mapped
		04	White cedar - (mixed conifer) / alder swamp (open phase)	**COLOR:** orange **CROWN SIZE:** small **CROWN SHAPE:** irregular **TEXTURE:** mottled & irregular	Mapped in wetland open settings where the canopy cover is generally less than 40%. Often transitional from denser wetland forests to sedge meadows.	Mapped

TABLE 2.1 - UNITED STATES GEOLOGICAL SURVEY and NATIONAL PARK SERVICE VEGETATION INVENTORY AND MAPPING PROGRAM PHOTOINTERPRETIVE SIGNATURE KEY - ISLE ROYALE NATIONAL PARK, MICHIGAN

08	Aspen - birch - red maple forest	**16C**	Aspen - red maple forest	**COLOR:** white (aspen) gray (red maple) **CROWN SIZE:** small to medium **CROWN SHAPE:** irregular **TEXTURE:** coarse	Extremely difficult type to separate out to the association level, mapped where red maple and aspen are visible on the photography, especially north of Siskiwit Lake and along the eastern portions of the Red Oak ridge. Aspen is a strong component to the overall canopy.	Mapped
		25A	Aspen – red maple rocky woodland	**COLOR:** Light with some gray **CROWN SIZE:** medium **CROWN SHAPE:** variable **TEXTURE:** coarse	An open woodland category, often sparse with rocky substrate on higher slopes and ridgelines.	Mapped
09	Maple - yellow birch - northern hardwoods forest	**08**	Maple – yellow birch – northern hardwoods forest (sugar maple phase)	**COLOR:** gray (visible white leaf litter layer under canopy) **CROWN SIZE:** large **CROWN SHAPE:** spreading **TEXTURE:** coarse	Pure stands of sugar maple were mapped as extensive stands at higher elevations above the boreal influence of Lake Superior. Sugar maple noted in the western portions of the Red Oak Ridge and Greenstone Ridge.	Mapped
		09	Maple - yellow birch - northern hardwoods forest (mixed phase)	**COLOR:** gray to dark gray (visible white leaf litter under canopy) **CROWN SIZE:** large **CROWN SHAPE:** irregular **TEXTURE:** extremely coarse	Usually mapped adjacent to PI type 08 at slightly lower elevations, in somewhat more mesic settings.	Mapped
		10A	Maple - yellow birch - northern hardwoods forest (yellow birch phase)	**COLOR:** brown and gray– some visible leaf litter under canopy attribute to maple. **CROWN SIZE:** medium to large **CROWN SHAPE:** irregular **TEXTURE:** coarse	Mapped primarily in the western portion of the island south of Windigo where yellow birch is a strong dominant in the canopy layer.	Mapped
10	Red oak - sugar maple forest	**11**	Red oak – sugar maple forest	**COLOR:** gray (visible white leaf litter under canopy) **CROWN SIZE:** large **CROWN SHAPE:** irregular **TEXTURE:** coarse	Mapped using a combination of photo interpretation signature and biophysical setting. Red oak is not separable on the photography in leaf off conditions. Mapped on upper south facing exposed slopes.	Mapped
12	Northern (laurentian) igneous / metamorphic moist cliff scrub	**60**	Northern (laurentian) igneous / metamorphic moist cliff scrub	**COLOR:** dark gray (darkness from photo shadows) **CROWN SIZE:** small **CROWN SHAPE:** narrow **TEXTURE:** coarse	Mapped as extremely narrow units along steep facing cliffs generally trending north.	Mapped
13	Mountain ash - mountain maple forest	**-**	-	Photo interpretation signature not established.	Not mapped, generally occurring below the minimum mapping unit.	Not mapped, MMU
14	Aspen - balsam poplar lowland forest	**-**	-	Photo interpretation signature not established.	Not mapped, several individual balsam poplar trees observed near Caribou Creek west of Siskiwit Bay. Below minimum mapping unit.	Not mapped, MMU

TABLE 2.1 - UNITED STATES GEOLOGICAL SURVEY and NATIONAL PARK SERVICE VEGETATION INVENTORY AND MAPPING PROGRAM PHOTOINTERPRETIVE SIGNATURE KEY - ISLE ROYALE NATIONAL PARK, MICHIGAN

16	White cedar - yellow birch forest	**21**	White cedar - yellow birch forest (cedar – birch phase)	**COLOR:** orange (cedar) dark gray (yellow birch) **CROWN SIZE:** medium to large **CROWN SHAPE:** irregular – large & spreading (yellow birch) conical (cedar) **TEXTURE:** very coarse	Mapped in mesic settings on north facing neutral or concave slopes where yellow birch is codominant with cedar in the canopy layer.	Mapped
		50A	White cedar – yellow birch forest (mixed phase)	**COLOR:** orange (cedar) dark gray (yellow birch), similar to PI 21 except with a component of lighter gray from paper birch. **CROWN SIZE:** medium to large **CROWN SHAPE:** irregular – large & spreading (yellow birch) conical (cedar) **TEXTURE:** very coarse	This signature is similar to PI type 21, but is mapped in slightly less mesic settings over larger areas. Signature type generally includes a paper birch component. Generally noted west of the Island Mine Trail.	Mapped
18	White cedar – black ash swamp	**-**	-	Photo Interpretation signature not established.	Grouped to Complex 200.	Complex
19	White spruce woodland	**-**	-	Photo Interpretation signature not established.	Grouped to Alliance 300. (White Spruce Woodland Alliance)	Alliance
22	Balsam fir / Canada yew woodland	**90**	Balsam fir woodland	Photo Interpretation signature not established.	Mapped on Passage Island based only on plot information. No photo interpretation signature established.	Mapped (locally)
23	Spruce – fir – aspen forest (open variant)	**53A**	Spruce – fir – aspen open forest	**COLOR:** generally pink **CROWN SIZE:** medium **CROWN SHAPE:** conical **TEXTURE:** coarse	A woodland similar to PI type 25 but with a more significant component of spruce in the canopy layer and a higher canopy density.	Mapped
25	Black spruce / Labrador tea poor swamp	**-**	-	Photo Interpretation signature not established.	Mapped to Complex 100.	Complex
26	Black ash - mixed hardwood swamp	**-**	-	Photo interpretation signature not established.	Mapped to Complex 200.	Complex
27	Red maple - ash - birch swamp forest	**49**	Red maple – ash – birch swamp forest	**COLOR:** dark gray **CROWN SIZE:** medium **CROWN SHAPE:** irregular **TEXTURE:** smooth	Noted in field reconnaissance only once in small depressions, photo interpretation signature not well established. Noted as rare type on island. Mapped sparingly (under 10 polygons) based on reconnaissance data.	Mapped (locally)
28	Great Lakes boreal talus woodland	**-**	-	Photo interpretation signature not established.	Not mapped. No PI signature established – noted as rare type on island.	Not mapped, MMU
29	Boreal rocky shrubland	**27**	Boreal rocky shrubland	**COLOR:** gray **CROWN SIZE:** small **CROWN SHAPE:** irregular **TEXTURE:** fine	Mapped as a shrub type with densities generally below 60%. Noted on upper slopes and ridgetops.	Mapped
31	Common juniper rocky krummholz	**26**	Common juniper rocky krummholz	**COLOR:** orange **CROWN SIZE:** small **CROWN SHAPE:** rounded **TEXTURE:** mottled	Frequently mapped in rocky outcroppings often with a minor component of spruce. Generally noted in the eastern portion of the island.	Mapped
32	Thimbleberry shrubland	**-**	-	Photo Interpretation signature not established.	Not mapped – generally below minimum mapping unit size.	Not mapped, MMU
33	Great Lakes basalt/diabase cobble-gravel lakeshore, shrub zone	**-**	-	Photo Interpretation signature not established.	Not mapped – typically below minimum mapping unit size.	Not mapped, MMU

TABLE 2.1 - UNITED STATES GEOLOGICAL SURVEY and NATIONAL PARK SERVICE VEGETATION INVENTORY AND MAPPING PROGRAM PHOTOINTERPRETIVE SIGNATURE KEY - ISLE ROYALE NATIONAL PARK, MICHIGAN

34	White cedar – balsam fir / leatherleaf / black crowberry krummholz	**83**	White cedar – balsam fir / leatherleaf / black crowberry krummholz	Photo Interpretation signature not established.	Mapped using plot information on Passage Island only.	Mapped (locally)
35	Canada yew mixed shrubland	**88**	Canada yew mixed shrubland	Photo Interpretation signature not established.	Mapped using plot information on Passage Island only.	Mapped (locally)
36	Speckled alder swamp	**28**	Speckled alder swamp	**COLOR:** gray **CROWN SIZE:** medium to small **CROWN SHAPE:** irregular **TEXTURE:** medium to fine	Mapped primarily as linear polygons often adjacent to cedar wetlands or sedge meadows.	Mapped
37	Sweet gale shrub fen	**-**	-	Photo Interpretation signature not established.	Not mapped, not discernable on leaf off photography. Grouped with Complex 100	Complex
38	Poverty grass barrens	**30**	Poverty grass barrens	**COLOR:** light **TEXTURE:** smooth but irregular	Mapped on rocky ridges where rock is the primary signature; sparse grasses may or may not be visible on the photography.	Mapped
39	Great Lakes basalt/diabase cobble-gravel lakeshore	**63**	Great Lakes cobble / gravel lakeshore	**COLOR:** variable **TEXTURE:** irregular	Mapped sparingly where shoreline width exceeds MMU requirements.	Mapped
		67A	Great Lakes cobble / gravel lakeshore – (undifferentiated gravel)	**COLOR:** variable **TEXTURE:** irregular	Mapped sparingly where shoreline width exceeds MMU requirements. Note: PI types 63 & 67A have been combined.	Mapped
40	Bluejoint eastern meadow	**31**	Bluejoint eastern meadow	**COLOR:** light **TEXTURE:** fine	Mapped using the photo signature and biophysical relationships. Generally found around the edges of larger meadows, especially in higher elevations.	Mapped
41	Northern sedge wet meadow	**-**	-	Photo Interpretation signature not established.	Not mapped. Relates to TNC Project Code 58.	Complex
42	Northern poor fen	**-**	-	Photo Interpretation signature not established.	Not mapped. Relates to TNC Project Code 59.	Complex
44	Boreal calcareous seepage fen	**-**	-	Photo Interpretation signature not established.	Not mapped. Relates to TNC Project Code 58.	Complex
45	Great Lakes shoreline bulrush - cattail marsh	**-**	-	Photo Interpretation signature not established.	Not mapped, generally below minimum mapping unit size. Community is rare, sampled only once on the Island.	Not mapped, MMU
46	Midwest mixed emergent deep marsh	**-**	-	Photo Interpretation signature not established.	Not mapped, generally below minimum mapping unit size. Noted as an uncommon type on the Island.	Not mapped, MMU
47	Water horsetail - spikerush marsh	**-**	-	Photo Interpretation signature not established.	Not mapped, generally below minimum mapping unit size. Noted as an uncommon and extremely narrow type on the Island.	Not mapped, MMU
48	Twig rush wet meadow	**-**	-	Photo Interpretation signature not established.	Not mapped. Relates to TNC Project Code 58.	Complex
49	Midwest pondweed submerged aquatic wetland	**-**	-	Photo Interpretation signature not established.	Not mapped, not discernable on early spring photography. Relates to TNC Project Code 98.	Complex
50	Northern water lily aquatic wetland	**-**	-	Photo Interpretation signature not established.	Not mapped, not discernable on early spring photography. Noted as uncommon on the Island. Relates to TNC Project Code 98.	Complex
51	Great Lakes basalt (conglomerate) bedrock lakeshore	**61**	Great Lakes bedrock lakeshore	**COLOR:** variable **TEXTURE:** irregular	Mapped sparingly where shoreline width exceeds MMU requirements.	Mapped
		67	Great Lakes bedrock lakeshore – (undifferentiated bedrock)	**COLOR:** variable **TEXTURE:** irregular	Mapped sparingly where shoreline width exceeds minimum mapping unit requirements. Note: PI types 61 & 67 have been combined.	Mapped
52	Great Lakes basalt/diabase cliff	**-**	-	Photo Interpretation signature not established.	Not mapped, generally below minimum mapping unit size (too narrow). Noted as uncommon on the Island.	Not mapped, MMU

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53	Paper birch / bush honeysuckle - fir forest	**12**	Paper birch / bush honeysuckle - fir forest	**COLOR:** light tan **CROWN SIZE:** narrow **CROWN SHAPE:** regular **TEXTURE:** fine	Mapped in post burn situations especially on the Feldtmann Ridge and portions of the Minong Ridge.	Mapped
54a	Aspen - birch / boreal conifer forest	**13**	Aspen - birch / boreal conifer forest (mixed aspen-birch phase)	**COLOR:** generally light, with some pink-red visible in the understory **CROWN SIZE:** medium **CROWN SHAPE:** variable **TEXTURE:** coarse	Mapped as a forest type (canopy generally over 60%) where the canopy layer is predominantly deciduous, usually more aspen than birch, with a visible understory of conifers, or where understory is not visible but is in close proximity to conifer types.	Mapped
		16B	Aspen - birch / boreal conifer forest (aspen phase)	**COLOR:** white **CROWN SIZE:** large **CROWN SHAPE:** irregular **TEXTURE:** coarse	Mapped where aspen is a strong dominant to the overstory (often clone-like in appearance) in a general area of mixed conifer – deciduous types.	Mapped
		25	Aspen – birch / boreal conifer forest (sparse canopy phase)	**COLOR:** Light brown to gray – exposed rock in places **CROWN SIZE:** small **CROWN SHAPE:** irregular **TEXTURE:** medium	Mapped as a sparse woodland with a dominant canopy of deciduous species and a minor component of spruce usually in the sub canopy.	Mapped
		53	Aspen – birch / boreal conifer forest (woodland phase)	**COLOR:** white (emergent aspen) over dominant magenta-pink (conifer understory) **CROWN SIZE:** small **CROWN SHAPE:** conical **TEXTURE:** fine (stippled)	Mapped where aspen and/or paper birch is a tall emergent to a dense understory of conifer. Most common in the eastern portion of the Island.	Mapped
54b	Aspen - birch / sugar maple - mixed hardwoods forest	**15**	Aspen – birch / sugar maple – mixed hardwoods forest (mixed phase)	**COLOR:** light gray to white **CROWN SIZE:** medium to large **CROWN SHAPE:** irregular **TEXTURE:** coarse	Mapped in transition areas between northern hardwoods and boreal types especially in the western portion on the lower slopes of the Red Oak Ridge. Aspen is generally a tall emergent to the northern hardwoods component.	Mapped
		16A	Aspen - birch / sugar maple - mixed hardwoods forest (aspen phase)	**COLOR:** white **CROWN SIZE:** large **CROWN SHAPE:** irregular **TEXTURE:** coarse	Mapped where aspen is a strong canopy component in an area where the northern hardwood species are common; occasionally visible in the understory.	Mapped
		55	Aspen - birch / sugar maple - mixed hardwoods forest (paper birch phase)	**COLOR:** light brown to white **CROWN SIZE:** small **CROWN SHAPE:** regular **TEXTURE:** fine	Mapped where paper birch is a dominant component to the overstory with a visible understory of sugar maple. Most common in the eastern portions of the Greenstone Ridge.	Mapped
55	Spruce - fir - aspen forest	**19A**	Balsam fir – aspen –paper birch forest	**COLOR:** magenta & gray **CROWN SIZE:** small **CROWN SHAPE:** narrow **TEXTURE:** coarse	Mapped as a mixed conifer (primarily fir) – deciduous type with at least 25% relative canopy cover of either.	Mapped
		20	White spruce - balsam fir - aspen forest	**COLOR:** magenta & white **CROWN SIZE:** small to medium **CROWN SHAPE:** irregular **TEXTURE:** coarse	Similar to signature PI type 19A, but with a strong canopy component of aspen mixing with the conifer species that are dominated by spruce.	Mapped
56	Spruce - fir and sugar maple - yellow birch mosaic	**54**	Spruce – fir and sugar maple – yellow birch mosaic	**COLOR:** mixed white & magenta **CROWN SIZE:** large **CROWN SHAPE:** variable **TEXTURE:** coarse	Mapped in areas where the mixing of conifers and sugar maple are clearly not ecotonal, often covering large areas.	Mosaic

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58	Sedge meadow complex	**32**	Sedge meadow complex	**COLOR:** white **TEXTURE:** fine to medium	Mapped to formation level in meadow environments. Early spring photography does not facilitate separating out the carex meadow types to alliance or association levels. Relates to TNC Project Codes 41, 44 & 48.	Complex
59	Sedge / sphagnum meadow complex+	**32A**	Sedge / sphagnum meadow complex	**COLOR:** white to orange **TEXTURE:** fine to medium	Mapped to formation level, the presence of a sphagnum layer differentiates this type from PI type 32. Noted as rare type (1 sample) on the Island. Relates to TNC Project Codes 42	Complex
60	White cedar - sweet gale scrub fen	**-**	-	Photo Interpretation signature not established.	Not mapped, included in complex 100 or with the northern tamarack rich swamp.	Complex
62	Spruce - fir basalt bedrock glade	**-**	-	Photo Interpretation signature not established.	Not mapped, included in Alliance 300	Alliance
63	Boreal pine rocky woodland	**51**	Boreal pine rocky woodland	**COLOR:** variable, mostly exposed surface light **CROWN SIZE:** large **CROWN SHAPE:** variable depending on species composition **TEXTURE:** coarse	Mapped primarily on exposed ridges where pines make up at least 25% relative cover, but absolute cover is sparse, usually below 25%.	Mapped
65	Northern tamarack rich swamp	**18**	Northern tamarack rich swamp	**COLOR:** light **CROWN SIZE:** medium **CROWN SHAPE:** variable **TEXTURE:** coarse	Mapped only in areas west of Siskiwit Bay where the deciduous conifers are visible in a normally sparse canopy, usually over carex type meadows.	Mapped
66	Black spruce / alder rich swamp	**-**	-	Photo Interpretation signature not established.	Not mapped – Noted as rare on the Island (2 samples)	Not mapped, MMU
67	Leatherleaf - sweet gale shore fen	**-**	-	Photo Interpretation signature not established.	Not mapped, grouped up to Complex 100.	Complex
70	Leatherleaf bog	**-**	-	Photo Interpretation signature not established.	Not mapped, grouped up to Complex 100.	Complex
72	Timothy - (bluejoint) seminatural meadow	**-**	-	Photo Interpretation signature not established.	Not mapped, below minimum mapping unit and often associated with land use categories.	Not mapped, MMU
74	Yellow birch - (spruce) forest	**50**	Yellow birch – (spruce) forest	**COLOR:** dark gray-brown with red **CROWN SIZE:** large **CROWN SHAPE:** irregular - spreading **TEXTURE:** very course	Mapped primarily in the western portion of the island in mesic settings in a mixed (25% minimum relative cover of either conifer or hardwoods) canopy layer. Paper birch may be a minor component to the canopy.	Mapped
98	Water	**98**	Water	**COLOR:** dark blue to black **TEXTURE:** smooth	Note that all water boundaries have been adjusted to register to the digital orthophotos. Relates to TNC Project Codes 49 and 50 except for Lake Superior.	Complex
99	Urban/built-up	**99**	Urban/built-up	**COLOR:** variable **TEXTURE:** irregular	Refer to the Land Use variable (see Data Dictionary) for detailed urban/built-up categories. Note: Does not relate to TNC Project Code.	Mapped

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100	Wooded peatland complex	**05**	Black spruce / dwarf-shrub swamp complex	**COLOR:** sparse pink over orange (sphagnum) layer **CROWN SIZE:** very small **CROWN SHAPE:** irregular **TEXTURE:** coarse – variable	Mapped where a sparse component of conifers (spruce) is found over a visible 'peat' layer. Shrubs may or may not be visible depending on size and density. Relates to TNC Project Codes 25, 60, 66(?)	Complex
		29	Dwarf shrub fen complex	**COLOR:** generally orange **CROWN SIZE:** extremely small **TEXTURE:** smooth – some stipple	Mapped in areas where ericads are visible as a shrub component to a sphagnum ground cover. Relates to TNC Project Codes 37, 67 and 70.	Complex
200	Black ash (white cedar) – mixed hardwoods swamp complex	**17A**	Black ash (cedar) – mixed hardwoods swamp complex	**COLOR:** dark gray with some orange **CROWN SIZE:** narrow **CROWN SHAPE:** variable (conical in cedar) **TEXTURE:** fine to medium	Mapped in wet areas where canopy cover is mixed hardwood-conifer. Cannot distinguish two black ash swamp types. Relates to TNC Project Codes 18 and 26.	Complex
		17	Black ash - mixed hardwood swamp complex	**COLOR:** dark gray **CROWN SIZE:** narrow **CROWN SHAPE:** irregular **TEXTURE:** fine	Mapped in wet areas where canopy cover is predominantly deciduous although sub canopy may be conifer. Relates to TNC Project Codes 18 and 26.	Complex
300	White spruce woodland alliance	**23**	White spruce woodland alliance	**COLOR:** pink **CROWN SIZE:** medium **CROWN SHAPE:** conical but irregular **TEXTURE:** coarse	Mapped to the super alliance – cannot reliably distinguish glade type from woodland type due to overlapping densities. Relates to TNC Project Codes 19 and 62.	Alliance